

The SoilC&N model: simulating short- and long-term soil nitrogen supply to crops

M. Corbeels^{1,2}

¹ Agro-ecology and Sustainable Intensification of Annual Crops, CIRQD, Avenue Agropolis, 34398 Montpellier, Cedex 5, France

² Sustainable Intensification Program, CIMMYT, United Nations Avenue, Nairobi, Kenya

Introduction

Carbon (C) and nitrogen (N) dynamics in the soil can be simulated by a number of approaches. Simple two-compartment models comprising a labile and stable organic matter pool can be analytically solved and parameter estimation for a given situation is relatively simple (e.g. ICBM, Kätterer and Andrén, 2001). However, these types of models do not incorporate important feedbacks of soil C and N to changing environment. More comprehensive models, such as CENTURY (Parton et al., 1987), have been developed for this purpose. Yet, most of these models do not consider explicitly microbial physiology as the driving factor of N immobilization-mineralization turnover, while this is fundamental for an adequate description of decomposition of soil organic matter (SOM) and soil N supply to crops.

Materials and Methods

The SoilC&N model includes above- and below-ground plant residue pools and three SOM pools (microbial biomass, Young and Old SOM) with different turnover times (Fig. 1). The distinctive features of this model are: 1) growth of microbial biomass is the process that drives N immobilization-mineralization, and microbial succession is simulated; 2) decomposition of plant residues may be N-limited, depending on soil inorganic N availability relative to N requirements for microbial growth; 3) N:C ratio of microbial biomass active in decomposing plant residues is a function of residue quality and soil inorganic N availability; 4) 'quality' of plant residues is expressed in terms of measurable biochemical fractions; and 5) C:N ratios of SOM pools are not prescribed but are instead simulated model output variables. Nitrogen is mineralized to, or immobilized from, the soil inorganic N pool to maintain the C:N ratio of decomposing microbial biomass within a specified range. Balancing potential microbial N demand against inorganic N availability determines whether the activity of decomposers is limited by N. If so, then simulated microbial use efficiency and decomposition fluxes are reduced.

Results and Discussion

SoilC&N can be used as a stand-alone model or coupled to a crop growth model to simulate within-season soil N supply from SOM and added organic sources to crops.

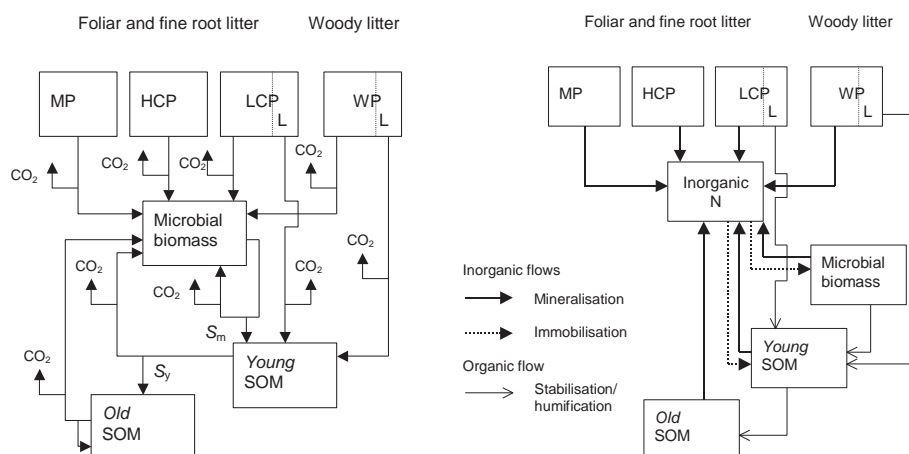


Figure 1. Pools and fluxes of (a) C and (b) N in the SoilC&N model. MP: metabolic pool; HCP: holocellulosic pool; LCP: ligno-cellulosic pool; L: lignin; SOM: soil organic matter; S_m: stabilisation coefficient for microbial biomass; S_y: stabilisation coefficient for Young SOM (from Corbeels et al., 2005).

The model responds to quality of added organic matter and predicts N immobilization or mineralization rates in time. The N immobilization peak depends on the biochemical quality of the plant residues and the available inorganic N. When soil inorganic N becomes severely limiting, decomposition of residues is slowed down. With a proper parameterization of plant residue 'quality', the model can acceptably predict N dynamics from crop residues ranging from green leguminous leaves to woody residues. Coupled to a crop growth model, SoilC&N is particularly suited for simulating the impacts of management or land-use changes on soil C storage and long-term N availability for plants. For example, the model is able to predict long-term storage of soil C following a change in land-use from forest to cropland, as a result of simulated changes in microbial activity, soil N availability and SOM C:N ratios to changes in plant residue quantity and quality. The incorporation of the feedbacks in the model between plant residue quality, N availability and microbial activity increases the mechanistic integrity of the model, compared to other models such as CENTURY or RothC (Coleman et al., 1997).

Conclusions

The ability of SoilC&N to adequately describe both short-term events such as soil N supply during one growing season, and long-term dynamics, e.g. soil C storage over several decades, is an important asset when coupling to a crop growth model.

References

- Coleman, K., D. Jenkinson, G. Crocker et al., (1997). *Geoderma*, 81: 29-44.
- Corbeels, M., R.E. McMurtrie, D.A. Pepper et al., (2005). *Ecol. Model.*, 187: 426-448.
- Kätterer, T. and O. Andrén (2001). *Ecol. Model.*, 136: 191-207.
- Parton, W.J., D.S. Schimel, C.V. Cole et al., (1987) *Soil. Sci. Soc. Am. J.*, 51: 1173-1179.